COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOMICS
STATE OF OKLAHOMA
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OKLAHOMA AGRICULTURAL AND
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TERRACING in OKLAHOMA

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FOREWORD

This circular is intended to point out the benefits of terracing to land owners and operators and to present a method of procedure in terracing whereby these benefits may be secured.

It is regretable that the first terracing effort of many farmers is wasted through failure on their part to observe the principles set forth herein. A half finished job of terracing is likely to result in wasted time, wasted effort and wasted soil and tends to bring into disrepute the most satisfactory means, so far determined, of preventing the enormous annual loss of soil fertility which now occurs. This loss constitutes a most serious drain upon the agricultural industry. It is very unlikely that any other industry could suffer such severe losses and survive.

The importance of measuring the slope to determine the spacing of terraces can hardly be over emphasized. Too heavy a grade or too much fall along the terrace line, can defeat the moisture conservation objective and may result in hillside ditches instead of terraces. Narrow water ways along the upper sides of terraces tend to the same result.

Failure to take into account the loss of height due to settlement of the dirt, when making fills in gullies, has resulted in much loss, in many instances.

Failure to provide suitable outlets for the terrace water is also an avoidable cause of loss.

The desire of many individuals to terrace as large an area as possible each season, often results in undersized terraces, weak fills and poor outlets. In such cases the same total amount of effort given to terracing half the area would result in greater protection and greater returns.

WASTING A HERITAGE

(Editorial from Daily Oklahoman)

"It is one of the tragedies of American development, this criminally careless waste of soil. State after state has permitted the fertility of the soil to become exhausted, thereby forcing the expenditure of uncounted millions in the arduous task of restoring soil fertility. How much better it would have been if the fertility of the soil could have been conserved from the first and the virgin richness of the land maintained undepleted.

Oklahoma is going the way of older states. The vigin soil was our heritage. Will coming generations be proud of the heritage left them?. We are as yet employing few measures to prevent the destruction of the land, which continues even though fields are thrown out of cultivation. A deed to the land wont hold the soil, and unless terracing, crop rotation and soil management are undertaken on an extensive scale, the next generation will receive as its heritage one of the poorest states in the Union."

The story of needless waste outlined in the above editorial is fully borne out by the survey of actual conditions recently completed by the A. and M. College, Stillwater, which shows that Oklahoma has in round figures, as of March, 1930

Total Acreage		36,000,000
Acres in cultivation		15,782,000
Showing as follows		
No erosion		2,319,000
Terraced		266,000
Sheet erosion	7,470,000	
Gullied	5,353,000	
Badly gullied	374,000	13,197,000
Total		15,782,000

This shows that the fertility is rapidly being washed away from 13 million of our 15 million acres in cultivation. With pasture land it is a different story. The survey shows we have—

Acres in pasture		15,175,000
Showing as follows,		
No erosion	14,419.000	
Gullied	756,000	15,175,000

which proves that we have known all along that grass and other roots prevent soil washing. Besides the 31 million acres just mentioned, the survey shows we have

Acres abandoned		1,694,000
Due to erosion	1,359,000	
Due to other causes	335,000	1,694,000

The pity of it all is, that nobody benefits from this enormous waste, while everybody suffers some injury from it, the farmer first and most directly.

There is more competition in farming than in any other business and more risks. Every wheat grower in the world is competing with every other wheat grower, the same being true of cotton growers and others. Yield per man per acre is the key to profits, and good yields go to good workers on good land with plenty of soil moisture. They are not possible on poor soils or with insufficent soil moisture. Good yields must be well sold of course, which is another part of the farmer's problem. The Federal Farm Board is helping farmers in this respect. Poor yields cannot be well sold, the world situation prevents it. The farmer who does not know his cost of production is groping blindly in the dark, his outlook is not cheerful.

TERRACING ONE OF THREE

In the editorial quoted, three factors necessary to successful farming were mentioned, terracing, crop rotation and soil management. This circular considers only one of these, terracing. We have not learned all there is to know about terracing. We do know that terraces of themselves add no fertility to the soil. They are a mechanical rearrangement of the surface of the land whereby loss of soil and plant food is largely prevented even in heavy rainstorms. Therefore, terracing is the first step for control and improvement of the thirteen million acres of our cultivated land now washing away. A huge task? Yes, but one that can be accomplished if landowners throughout the state will realize their own necessity and turn to with a will to succeed. It is a job that cannot be passed on to George or any other agency. Half built terraces are worse than no terraces at all. Inspection of many terraced fields following recent heavy rains (May 1930) when 3.22 inches fell in one hour at Guthrie, and 0.85 inches fell in one ten minute period, which is at the rate of over five inches in one hour. This inspection showed that where terraces had been built full twenty-four inches high they held, they were water soaked almost to the top, but no breaks occurred in the line. The condition at terrace outlets was noticable. More will be said later regarding outlets.

HOW IT STARTED

Although terracing has been practiced by agriculturalists from the earliest times, as the most successful method of preventing soil erosion, it seems to have been left for American farmers to modify ancient practices so as to fit them to modern conditions. As practiced in ancient times, terracing consisted of building land up in series of level areas separated by almost vertical walls. This type, know as the bench terrace, is still used to some extent on the steeper lands and in landscape gardening in the United States. Strictly speaking this is the true terrace, but as applied to the protection of farm lands, a terrace is now defined as any arrangement or disposition of the soil, the object of which is to retard the rapid movement of surface water.

The problem of preventing soil erosion in this country came up for early consideration in the southeastern states, where the loss in fertility of the light natured soils which had been put under the plow, quickly became apparent. It was soon found that the bench terrace was a serious obstacle to the use of improved farm machinery and efforts of farmers in that section were directed to devising ways and means of overcoming the difficulty. The attention of the United States Department of Agriculture was directed to the efforts being made in the southeast section when the farmers' efforts had met with considerable success. An agricultural engineer was sent to make a study of the methods used, the degree of success attained by individual farmers and the factors making for their success or failure. This man, Mr. C. E. Ramser, made a thorough study of conditions in the Carolinas, Georgia, Alabama, and Mississippi. The report of his findings was published in 1917 and has become the basis for the terracing efforts of extension agricultural engineers in other states. Among the many varieties of terraces studied, it was found that those on the farm of Mr. P. H. Mangum near Wake Forest, North Carolina, most nearly gave the desired results and were therefore to be recommended to other farmers. The Mangum terrace, as it is now known, is today the most commonly used type and is the only one discussed in this bulletin since it most nearly meets all the requirements of this state.

SOME PROGRESS MADE

Profiting by the knowledge gained in the southeast, farmers in other states became interested in terracing work. Much additional information has been obtained from subseqent terracing effort. Even when failure of the terraces to carry storm water occurred, the cause of such failure has been distinctly traceable and carefully noted so that failure from the same cause might be avoided in the future.

The most common causes of terrace failure are discussed in this circular. Probably each state has its own problems in erosion control. We have three conditions to reckon with which makes our soil loss from rain washing particularly great. They are:

1. A loam soil which is not able to resist the action of moving water. It has little clay and much sand in most sections, and is separated easily into sand and plant food by heavy rains.

2. We have a rolling country, slopes are everywhere and range from gentle to very steep. Soil moves down hill easily.

3. We are subject to many heavy dashing rains, when the water falls in such quantities as to be an active force.

Because of past effort in this state, the attention of the U. S. Department of Agriculture has turned to Oklahoma. A federal erosion research experiment project is established at Guthrie where Mr. C. E. Ramser who is now the foremost authority on terracing, has been put in charge of the station. Mr. S. W. Phillips of the Bureau of Chemistry and Soils is in charge of the work of that department. The efforts of these men will be of great value to us as their studies progress. Visitors to Guthrie should inquire at the post office building for these men, or at the station farm which is four miles south of town on highway 77 and one-half mile east. A signboard marks the corner turn.

EROSION

There are two forms of erosion. The one known as gully erosion is quickly apparent to the farmer and soon causes him lively concern. Gullies and ditches of varying sizes occur in the field, showing unmistakably where fertile soil has been carried away by storm waters. Terracing is the first step for prevention and cure. The other form, known as sheet erosion, is not so quickly apparent and is therefore more dangerous. In sheet erosion a thin layer of topsoil is moved more or less evenly, floated off as it were, from considerable areas. The soil movement is slower, the appearance of the field is not disturbed; nevertheless, large quantities of the rich humus content of the soil are removed and carried off in streams and freshets. Eventually the lowered crop yield is noticeable, by which time from six to eight inches of topsoil may have been lost to the owner. Sheet erosion is more likely to occur and is much less apparent in the small grain growing sections of the state as the plant roots more nearly occupy the whole area or seed bed, tending to prevent the formation of gullies thus strengthening the owner's belief, that in his case, terraces are not necessary.

That this belief is wrong is shown by the college survey figures for Garfield County in the wheat growing section. The figures show

Acres in cultivation		515,402
No erosion		95,785
Terraced		2,573
Sheet erosion	326,489	
Gullied	86,889	
Badly gullied	3,666	417,044
Total		515,402

Sheet erosion is taking heavy toll in the northern half of Oklahoma. The thousands of well terraced acres there are proof that modern large scale machinery can be used successfully on terraced land.

Most of those who give thought to the subject, think of terracing only as a method of preventing erosion. That used to be the only compelling thought and largely explains why more acres are terraced in the southern half of the state, for there the row crop system of farming most largely obtains and gully erosion is quickly apparent under such a system. Actual results from terracing in the past few years show that the prevention of erosion is only part of the story. The conservation of soil moisture and the possible increase of soil fertility is the other part of the story.

Rainfall in most sections of the state is not always well distributed. It often occurs as very heavy downpours during short periods, with the result that much of the valuable moisture is lost as run-off water, which carries with it fertile soil in large quantities.

ADVANTAGES POSSIBLE

Soil and water are necessary to production. Water in large quantities moving rapidly, is the farmer's enemy. Water in small quantities and moving slowly, is the farmer's real friend. Except under the irrigation system of farming, we cannot control the supply of water but with terraces we may regulate not only the quantity on any given area but also the speed at which it moves. Therefore, with terraces we can largely eliminate water as an enemy and restrict it to beneficial uses.

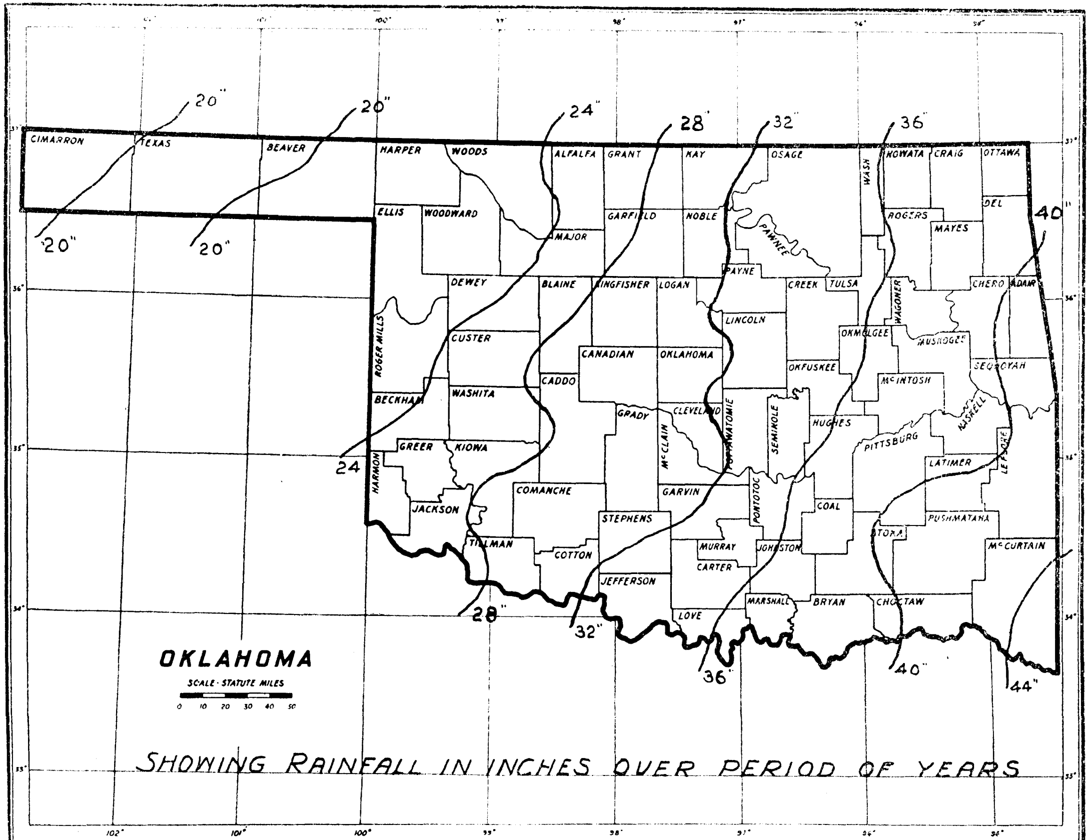
In crops, 200 to 500 pounds of water, or from 24 to 60 gallons, are required to produce one pound of dry matter. Ordinarily, then, the Oklahoma farmer can ill afford to allow his rainfall to escape as run-off water, even from comparatively level areas. The importance of humus, or decayed vegetable matter, to profitable production is generally underestimated. Humus not only increases soil fertility or the amount of plant food available in soil, it also increases the water holding capacity of a soil. If a wire screen-bottomed box 12 inches square, filled with soil that is deficient in humus will absorb one gallon of water; the same box full of soil that is rich in humus, will absorb two gallons of water. The humus filled soil not only absorbs twice as much water, it will also hold it twice as long against the forces of evaporation, the sun and the wind, which tend to draw it out of the soil.

The full vision of terracing, then, takes into account the prevention of erosion, the conservation and increase of soil moisture and the possibility of increaseing soil fertility. In this connection it might be well to quote a recognized authority in soil chemistry, Cyrus G. Hopkins, who in his book, "Permanent Agriculture," states that, "One ton of clover hay turned under is equal to four tons of average manure." We cannot get all the manure we would like to have, but it is possible to grow two tons of sweet clover per acre in many Oklahoma counties.

A rainfall map of Oklahoma showing the average rainfall for the past twenty years is shown here in the hope that it will indicate those sections of the state where terracing will pay from a moisture conservation viewpoint, alone.

Average rainfall records have little or no bearing on terracing for erosion control. It is intersity of rainfall that counts in this connection. If four inches of rain occur in four hours, and one inch of that falls in ten minutes, the ten minute period will cause greater soil loss than the balance of three inches falling in a longer period. Rain gauges recording intensity of rains are not common. There are some now in operation at Guthrie and at Stillwater.

RAINFALL MAP OF OKLAHOMA



THE FARM LEVEL AND ROD

With thirteen million acres of land to be cared for, the use of the farm level and rod should spread rapidly in Oklahoma. By the end of 1929, 1006 of our farmers had learned how to properly use these instruments which they owned and used in runnnig their own terrace lines on over 55,000 acres of land. The same men are busy again in 1930 and will roll up an even greater total of terraced acres.

Only one type of farm level and rod (that shown in Figure 1) will be considered here. Instruments similar to the one shown can be purchased at moderate prices. They are very useful in laying out straight fence rows and ditch lines, and in squaring and levelnig foundations for farm buildings. Their use effects a great saving in time when terracing, and results in better control of the work. Directions are sent out with each instrument by the manufacturer. More than 1000 farm rods and levels are now owned by Oklahoma farmers.

A bubble tube such as is found in the carpenter's level is an essential part of every farm level, so also are the cross hairs which are seen to form a cross when looking through the telescope, corresponding to the cross on the target of the rod. With the aid of the bubble tube, the telescope can be maintained absolutely level while being turned through all points of the compass, when one line of the cross will be truly vertical or straight up and down, the other line of the cross will be truly horizontal or level at right angles to the vertical.

The level head, which is screwed to the tripod legs, consists of a base or screw plate, three leveling screws, a telescope or degree plate and the turret which carries the telescope, bubble tube, and a straight vertical line marked on the outside of the turret by means of which angles turned by the telescope may be read. The telescope plate is fastened to the base plate by a screw bolt carrying a coil spring, the purpose of which is to maintain snug tension between the two plates when in use. Under the telescope plate will be found two little parallel bars made as part of the casting to engage one of the leveling screws to prevent turning of the telescope plate. When in use, all parts of the farm level should be snugly tight, not excessively tight, in order that good work may be accomplished.

THE TARGET AND ROD

Through its color divisions, the target on the rod shows cross lines similar to the cross in the telescope. Behind the target and in line with its horizontal line will be found a metal pointer indicating all the time the position of the horizontal line of the target on the rod. Most level rods are made in two sections which slide one upon another so that a short rod and a long rod are available for use. The rod is divided into feet and inches, or feet and tenths throughout its lenght, and is intended to be self reading. When used as a short rod, the pointer behind the target gives the rod reading. When necessary to use the long rod, the short rod should first be used to its full extent, that is the target pointer should be on the five foot mark of the long rod, corresponding to the top of the short rod, in order to enable the operator to make direct readings of the long rod which are then taken at the top of the short rod. If the short rod is not entirely used up before extending the long rod, mental calculations must be made to determine differences in rod readings and mental calculations are dangerous because of the liability of error.

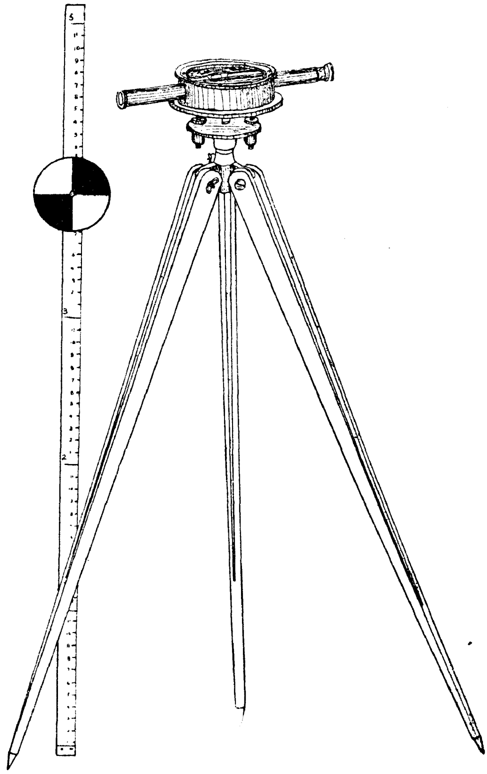


FIGURE NO. 1—AN INEXPENSIVE FARM LEVEL

To Use the Farm Level, the instrument is set up by spreading the tripod legs and pushing them into the ground until the instrument stands firm, with the telescope plate almost horizontal. The leg screws should be loose when carrying the instrument and tightened before leveling up. The telescope is leveled by means of the leveling screws, until the bubble in the bubble tube shows that the telescope is precisely level, no matter in which direction it is turned. This leveling process may be accomplished in short order by observing the following—when spreading the tripod legs, see that the base plate is practically level, put one leveling screw between the parallel bars and run all three screws up until nice tension is obtained in the coil spring. Turn the telescope and bubble tube across two of the three screws, manipulate both until the bubble is at the center. Turn the telescope about one of the two screws until it is across the third screw and the turn screw. Manipulate the third screw only until the bubble is at center. Turn telescope back to first position to check, and if necessary, manipulate the outside screw only, not the turn screw, until the bubble is again centered, turn to second position and repeat, checking both positions until the bubble remains at center. It will be noted that after the first manipulation the turn screw is not touched. When the bubble remains at center for both positions, it will remain centered for all positions of the telescope, provided the level is in adjustment. A little practice with this method will enable the operator to set up the level very quickly. When sighting through the telescope, if it is properly focused, the crossed hairs are seen; one vertical, one horizontal. The telescope is focused by manipulating the eye piece. The horizontal color divisions of the target on the rod are brought in line by the rodman at the direction of the instrument man, with the horizontal hair in the telescope. The target marker will now be pointing to a definite mark on the target rod. If the rod is moved to a different location, the target must be raised if the rod is moved down hill, or lowered, if the rod is moved up hill, to again coincide with the horizontal hair of the telescope which has not moved. The target marker will now be pointing to another definite mark or rod reading. The difference between the two rod readings represent the true diffreence in elevation of the two locations.

The instrument man directs the movement of the target on the rod by hand signs. one hand held above the head means the target must go up. One hand held below the knees means the target must go down. Both hands thrown out in line with the shoulders means the target is in correct position. When one has mastered the use of the farm level and rod he should rely upon it in preference to his natural eye. Almost invariably a terrace line will appear to run uphill, or opposite to the desired result. This is because the natural eye is not able to determine slight differences in elevation as effectively as may be done with the rod and level. It is well to check such lines when doubt exists, to prove that no mistake has been made. It is also good practice to check the grade of the waterway of each terrace immediately after it is built to see that no dangerous changes in the grade have occurred during construction.

Sizing up the Area to be Terraced. The first thing to be done in terracing a piece of land is to learn all you can about the conditions present. Its drainage with relation to surrounding fields should be considered. Water coming from unterraced land above must be cared for. If necessary such water may be diverted by means of a levee or ditch or combination of both. Sometimes a definite starting plan for terracing the whole farm will avoid changing terraces built previously without thought to the needs of the farm as a whole. The general direction of flow in main streams will indicate this general slope. When possible terraces should discharge water opposite to the direction of flow in main streams. The type of surface soil present, the number and size of gullies, the subsoil and the probable length of the terrace lines should all be taken into consideration when planning a system of terraces.

In sizing up the area, the location of terrace outlets should be given very careful thought. Generally speaking, Oklahoma farmers cannot afford to let rainfall escape as run-off water if any possible use can be made of it by turning it into a pasture or meadow or woodlot or into a stock pond. Wasting the water into a ravine or gully or other unusable place on the farm is preferable to putting terrace outlets at roadside ditches, for by wasting the water away from the road, great savings in road maintenance may be effected. It is true that well terraced land largely prevents run-off, yet during the occasional heavy flooding rains large quantities of water will discharge from terraces. The aim of everyone should be to prevent damage from this discharge. To the individual farmer who finds that a roadside ditch is his only possible outlet, the advice of the Extension Service is to discuss the problem with the county commissioners for the district, or other road authorities **BEFORE BUILDING** the terrace. In practically all cases a reasonable agreement will be reached. Remember that the men responsible for road maintenance have a big problem of erosion control, and they do not want additions to their burden thrust upon them without their consent. In many counties of this state the local road authorities' sympathies are with the farmer heart and soul in this big problem of erosion control which confronts us all.

Orchard land should be terraced before the trees are set out. In many cases this is not done and if sheet erosion is occurring some compromise whereby both the soil and the trees may be cared for should be carried out. The compromise plan may result in fewer trees per acre since it is not wise to leave trees in the terrace waterway where they would interfere with maintenance work. However, orchard yield can confidently be expected to increase when the loss of plant food, or soil fertility, is prevented through terracing.

Planning the Terrace System. The logical place to start a system of terraces is from the highest point of the water shed or catchment area. The location of the first terrace and every succeeding terrace should not be a matter for arbitrary decision. The natural slope of the land, the ability of the soil to absorb moisture and the water shed or catchment area presented to each terrace, should determine its location. On cultivated land water becomes a destructive force when it has quantity or speed, or both. A terrace system is designed to cut down quantity and speed of water on a given area. When planning the terrace system we should remember that it is not the ordinary rain we are fighting, it is the extraordinary rain that does great damage. Water is such an immense force that every advantage possible to man in combatting it should be made use of. It is a real advantage to put the top terrace way up high on the slope. It is the key terrace since if it breaks, all others below are almost sure to break. The aim of the farmer should not be to put as few terraces as possible on his slopes. His aim should be to put as many terraces as are necessary to insure him the greatest benefit possible. We do have rainfalls at the rate of four inches or more in one hour. What does this mean to terraces? One acre is roughly, 210 feet square, then if terraces happen to be spaced 105 feet apart horizontally, and are 1700 feet long, there will be four acres in the catchment area or watershed. A four inch rain is equal to one-third of a foot, and an acre has 43,560 square feet of surface area. 43,560-thirds gives 14,520 cubic feet of water in one four inch rain to the acre. Each cubic foot of water is equal to seven and one-half gallons and 14,520 X 7½ is equal to over 100,000 gallons of water. With these heavy rains very little of the water has a chance to soak into the ground because it smears the surface with a sealing effect. Rain does not have to fall the full hour to do damage. Terraces will be carrying at this rate and discharging at this rate as soon as the rain has fallen long enough at this rate to discharge at the outlet, the water collected at the upper end of the terrace. Ask yourself the question, "What is a reasonable watershed or catchment area for terraces?" and remember they will have to face four inch rainfall conditions or worse. If, with plenty of humus in the soil to increase the rate of absorption, each terrace was made to back water during storms to the base of the terrace immediately above, no loss of soil or water need occur. We are a long way from such conditions yet, but the nearer we approach them, the more profitable will each harvest be. The steeper the slope, the faster will run-off be delivered to the terrace, and speed in water is destructive. Therefore, we should measure the slope for EACH terrace and space them according to our best judgment when all the facts are known.

To Locate the First Terrace, set the level up at a point on the slope from which the highest point of the watershed can be overlooked. The level is not set on the high point which is the location for the rod. The highest point can easily be determined by sighting the target in line with the horizontal hair of the telescope as described under Using the Farm Level, the rod being held on locations which the natural eye indicates as being the probable high points. The high points being found the rod reading is noted and the rod moved down hill 100 feet along the line of average slope, when the target is again sighted in line and the rod reading noted. (See Fig. 2) The difference between the two readings will be the fall or natural slope of the ground in 100 feet. We cannot always determine the line of average slope by observation. It then becomes necessary to measure in two or more places, add the differences obtained, and divide by the number of measurements taken to obtain the average slope. For instance, the hill may slope three ways, to the west at the rate of 3 feet in 100 feet, to the south at the rate of 1 foot 6 inches per 100 feet, and to the east at the rate of 5 feet in 100 feet. Three feet plus 1 foot 6 inches plus 5 feet equals 9 feet 6 inches. Dividing this by 3, the number of measurements, we get 3 feet 2 inches for the average slope of the top 100 feet of the hill.

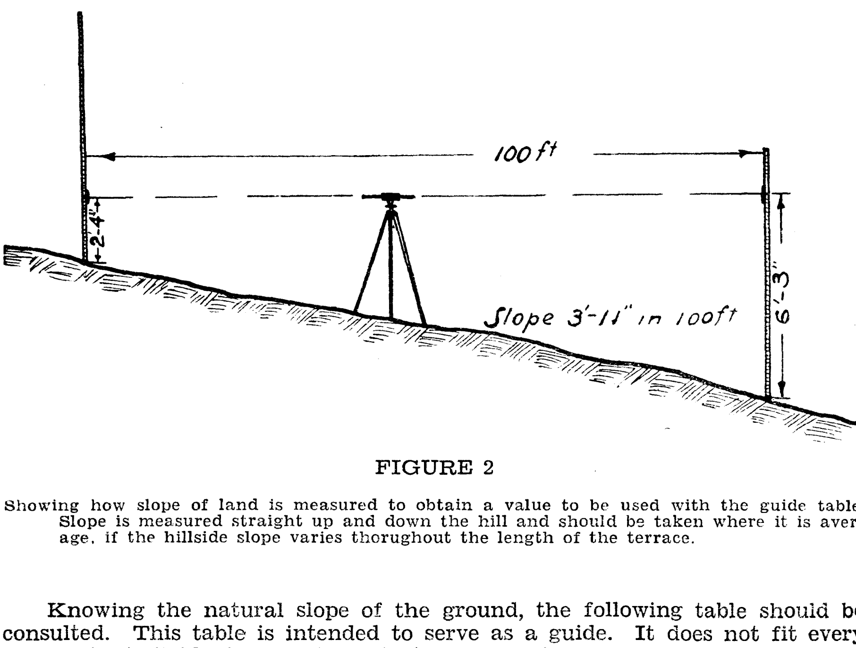


FIGURE 2

Showing how slope of land is measured to obtain a value to be used with the guide table. Slope is measured straight up and down the hill and should be taken where it is average, if the hillside slope varies thorughout the length of the terrace.

Knowing the natural slope of the ground, the following table should be consulted. This table is intended to serve as a guide. It does not fit every case. The individual's experience in terracing, his farm sense, good judgment and knowledge of his soil, should be used with the table. If the virtical fall indicated by the table results in too great a catchment area being given to the terraces, then less vertical fall should be used. The left hand and the middle columns are used; the right hand column gives the result obtained from using the other two.

This table is based on several years experence in Oklahoma and may be safely relied upon by those lacking practical experience.

A Guide to the Proper Spacing of Broad Base Terraces

When the Slope of the Land in 100 ft. is	Give a Vertical Fall Between Terraces of	Distances Between Terraces will then be about
1 ft.	1 ft. 9 in.	175 ft.
2 ft.	2 ft. 6 in.	125 ft.
2 ft. 6in.	2 ft. 9 in.	110 ft.
3 ft.	3 ft.	100 ft.
4 ft.	3 ft. 4 in.	80 ft.
5 ft.	3 ft. 6 in	70 ft.
6 ft.	3 ft. 7 in.	60 ft.
7 ft.	3 ft. 10 in	55 ft
8 ft.	4 ft	50 ft.
9 ft.	4 ft. 6 in.	50 ft.
10 ft.	5 ft.	50 ft.

With the high point of the area to be terraced known, and also the natural slope of the field in 100 feet, the vertical spacing for the terrace is determined with the help of the guide table. In effect, the table advises a definite vertical spacing for a definite natural slope. To obtain the spacing the instrument is set up near where the upper end of the terrace will come and overlooking the high point on which the rod reading is taken. To the high point reading add the vertical fall indicated by the guide table, set the target on the rod at the sum of the two and proceed to find the location of the upper end of the terrace. Very often the slope can be measured and the upper end of the terrace located from the one set-up of the level, in which case the guide table recommendation is added to the high point reading to obtain the vertical fall. For example, the rod reading on the high point (See Fig. 2) is 2 feet 4 inches and the slope of the land 3 feet 11 inches, which when referred to the table indicates that a 3 foot 4 inch spacing should be used, then the target should be raised to 5 feet 6 inches which is 3 feet 4 inches plus the high point reading. The rodman now moves to where he thinks the upper end of the terrace will occur and holds the rod for the instrument man to sight upon. The instrument man motions the rodman up or down hill until the horizontal line of the target is in line with the horizontal hair of the telescope. When they are so in line, the rod will be on the first or high point of the terrace line. The target is now raised on the rod to give the amount of grade decided on, and the rodman moves 50 feet or 100 feet, as the case may be, to what he thinks will be the next point on the terrace line, when the instrument man again motions him up or down the hill until the the line of the terrace. This process is repeated until the rod is too far from cross hair again coincides with the target line, when the rod will again be on the level for accuracy, when it becomes necessary to move the instrument to a new position beyond the rod. To do this, the rodman holds the rod at the last point of the terrace line determined, being careful not to lift the rod from the ground. The instrument man moves his level to a new position, levels the telescope and sights back on the rod, motioning the rodman to move the target up or down on the rod until the cross hair coincides with the target line. The rodman now raises the target the amount of grade necessary, and proceeds as before.

It should be noted in the foregoing that sometimes the rod is moved, the target remaining stationary on the rod, and sometimes the target is moved, the rod remaining on location.

To Locate the Second and Each Succeeding Terrace. After the first terrace has been run, the terrace line above becomes the high point of the remainnig area to be terraced and is therefore the high point from which to measure the natural slope in 100 feet, to determine the location of succeeding terraces. The natural slope should be measured where it represents average conditions.

Set the instrument up a little below the upper terrace, preferably at a point from which average conditions of slope and also the probable high point of the terrace are in range of the telescope. Read the rod held on the upper terrace by sighting the target in line with the horizontal hair of the telescope as already described, measure the slope in 100 feet and consult the guide table. When the vertical spacing has been decided upon proceed to find the high or first point of the new terrace, as already explained.

Many variations in methods for running terrace lines are possible. The method given is good practice and easily understood. In this method the operators are working from the high points of the terrace line all the time. This necessitates considerable walking but gives better control of the work.

Running the Terrace Line. At least two men are necessary for this work, one man with the leveling instrument and one man with the rod. The rodman should also carry a hoe with which to mark the points on the terrace line as they are determined, by raising a mound of dirt at each point. If stakes are used to mark the terrace line, a third man is necessary to carry and set the stakes. The manufacturer's instructions sent with each leveling instrument advises that longer sights than about 200 feet can not be depended upon for accuracy. This is good advice and should be heeded.

It has often been said that the rodman builds the terraces and much depends upon the rodman's good judgment. He is responsible for the correct grade of the terrace and should exercise care when holding the rod to be sighted upon, avoiding uneven spots in the ground surface. When working to such small grades is two or three inches in 100 feet, errors can easily occur which would defeat the purpose of the work.

The level man must keep his instrument precisely level at all times. Unless the bubble exactly centers the bubble tube, errors of several inches in a distance of 200 feet are easily possible. The level man should carefully note all actions of the rodman to prevent errors, as it sometimes happens that the target is raised on the rod when it should be lowered, or vise versa. The level man should detect all such false moves.

It will be well at this point to summarize what has already been written regarding terracing methods. By so doing we can get clearly in mind what may be considered.

THE FIRST FOUR STEPS IN TERRACING

These are highly important, especially for beginners in the work, because if followed with care and in the order in which they are given, these four steps will in most cases lead to a successful job of terracing.

1. Size up the area.
2. Find the high point of the area, and measure the slope.
3. Consult the guide table, page 16, and decide upon the vertical fall.
4. Run a trial terrace line.

Step number one involves walking over the ground to be terraced, having in mind the type of topsoil and subsoil presented, the area of the watershed, the natural slope of the ground, the number and size of gullies present, the probable length of terraces, outlet locations, etc. See page 13.

Step number two is explained fully on page 15.

Step number three is indicated on page 16.

Step number four is given on page 16. It is well to consider the top terrace line as a trial line until its location is definitely assured. The top terrace is the key terrace of the system, if it breaks during a heavy rain, then all below it are almost sure to break. For this reason it is a wise plan to put the top terrace way up near the top of the slope, remembering that water in small quantities and moving slowly is the farmer's friend.

FIGURE 3
This picture shows an experimental terrace where a constant grade of six inches was used.

The Grade of a Terrace. By grade of a terrace we mean the number of inches fall we give to each 100 feet of its length. The grade used may be constant, as when the same number of inches fall is given to each 100 feet of length, or the grade may be variable, as when the fall given is gradually increased from the upper to the lower end of the terrace. The variable grade offers advantages when the terraces are long. By giving less fall at the upper end, the water moves more slowly, giving the water at the lower end more time to discharge and by giving more fall at the lower end where more water passes, the discharge is hastened.

The constant grade is now seldom if ever used in Oklahoma. Short terraces are more easily maintained than long ones. It is therefore best to keep the terraces as short as practicable without making the outlet ditches too numerous. It is best to keep the terrace length, along which water is carried in one direction, under 1200 feet. If the water is carried both ways from the divide or high point of the terrace line, this would result in a total length of 2400 feet, provided the divide occurred in the middle of the terrace line. Sometimes it is advisable on a large smooth field to carry the water much farther than this to reach a suitable outlet. Terraces may safely be made long when the catchment area is not too great, when the soil will readily absorb rainfall, and where the terrraces are not too crooked, or the field badly gullied. Terraces have been made one-half mile long successfully, but such lengths should be avoided whenever possible.

The Grade to Use depends upon the type of soil, how easily it is moved, and its ability to absorb moisture, and upon the length of the terraces. Remember that one object of terracing is to hold as much water in the soil as possible, therefore slow movement is desirable. A variable grade terrace might well have a hundred feet or more at its upper end run level, then a section with a one inch grade, then a section with a two inch grade and so on. Generally speaking Oklahoma soils will erode into ditches when a constant grade of four inches in 100 feet is used. Fig. 3 shows an experiment station terrace at Stillwater, to which a constant grade of six inches was given. Although only about 900 feet long, this terrace waterway, as will be seen, is washed down to plow sole, and is acting as a ditch. Under average conditions of slope and soil, a terrace 1600 feet long could have a variable grade as follows:

At the upper end,	200 feet	level
then	200 feet	1 inch grade
	900 feet	2 inch grade
	300 feet	3 inch grade
	1600 feet	2 feet 5 inches total fall

Some farmers put their terraces too far apart in order to avoid hard work and give excessive fall to their terrace lines, so that the terrace shall carry the water without breaking. This is a mistake. Other men, anxious to prevent all loss of plant food and moisture, want all terrace lines run level. Level terraces do have practical application in some localities as the following report from the Goodwell Station shows.

Goodwell Experiment Station, Texas County, Oklahoma

(Project 11, A. D. McKinley)

A 20 acre field which was broken from native sod in 1924 and which has been uniformly cropped since that time was divided previous to the 1926 planting of milo into halves, the upper one being terraced with low broad terraces level grade on 6 inch steps, six terraces being required for the 10 acres. Otherwise both fields were treated alike.

The yields for 1926 were 637 pounds of grain per acre on the unterraced field and 950 on the terraced field. The effect of the terraces was easily noted by the eye from the time the crop was well headed out. It should be noted that only one rain occurred in this crop season which was great enough to run off, being 2.71 inches on the 25th and 26th of June and it was apparently from the effects of holding this water on the field that the above results were secured. These terraces will be maintained and the experiment continued on the other crops of the livestock rotation."

It should be noted that the natural slope of the land for this experiment is 6 inches in 100 feet or less. Short terraces on gentle slopes, say 3 feet in 100 feet or less, could be well run level with both ends open. Terraces up to 800 feet long could probably be maintained under such conditions. The surface of the average field is usually in such condition that a grade of two inches, 2 inches fall in 100 feet, is no more than a general assurance that the terrace is not runnnig uphill, and full height terraces must be built to care for the water on two and three inch grades. It is not at all easy to run a level terrace with precision on the ordinary field. Sometimes a field slopes four ways with no outlet available. In such cases it may be advisable to run a level terrace, closed ends, using a vertical spacing of not more than two feet, and building the terrace fully two feet high. This results in ponding water practically all over the top of the hill during a heavy rainstorm. The ideal method in such a situation would be to construct an under drain tile line to an available outlet, with the inlet in the terrace waterway. Such work is costly though effective.

The ponding effect of level terraces with closed ends can be quite serious if top soil or subsoil is of an impervious nature permitting little or no percolation. Fig 4 shows water standing for weeks in a level terrace during a rainy period on land with an impervious subsoil. The crop of course is badly drowned out.

FIGURE 4

Level terrace with closed ends on the Guthrie Federal Erosion Research Farm.

Crossing Gullies. When marking the terrace line, average ground should always be selected upon which to hold the rod. Where elevations or depressions are sharp, or when the line twists and turns considerably, stakes should be set closer together than on even ground. In running a line across a badly gullied field, unless the gullies are very broad, it is a good practice to set one or more stakes on each ridge between gullies and no stakes in or near the gully. When this is done it is intended to build the terrace straight across the gully and to fill in the necessary dams in the gullies. It is best to build the fills before building the terraces. When the gully is broad, 50 feet or more, it is sometimes undesirable on account of the work involved to run the terrace straight across the gully. In this case the terrace is curved up into the draw so that the fill will not need to be so great, and at least one stake is set in the gully to mark the line. If such a draw can be made the high point of a terrace line draining to both ends it is a considerable advantage. Dams and fills must be built strongly. Water concentrates at these points. They must also be built higher than the terrace on either side. Loose soil compacting or settling will lose one-fourth or more of its height, therefore, allowance must be made for this settling when building fills.

Hundreds of terraces have failed in this state because farmers have failed to make allowance for extra settlement of loose dirt in gully fills. If a gully four feet deep is to be crossed with a two foot terrace, there will be six feet of loose earth in the gully and two feet of loose earth in the terrace on either side of the gully which in settling will lose one-fourth of its height or six inches while in the gully the settling will be one-fourth of six feet or eighteen inches. Therefore, the gully fill should be made at least to a height of seven feet six inches and closely watched.

The Terrace Line. Experience shows that when a person has mastered the art of terracing to the extent that his work proves satisfactory on one or more jobs, that person is inclined to seek varying methods of doing the work, and is entitled to, and does express personal opinions regarding practices that may be used. This is a healthy condition making for progress. At the same time it is a mistake to condemn proved methods or to stoutly acclaim personal opinions as correct. What may be success in one situation, may be failure in another.

Heed not the new while proof is meager,
Be willing to believe, but not too eager.

In five years of Extension Service in terracing in Oklahoma, the writer has not yet found two hills exactly alike. In fact no one hill has been found to have the same per cent of slope from top to bottom. This certainly points the necessity of measuring the slope for every terrace. It has been argued that the surveyed line MUST be made the water line of the terrace. Others may argue that the surveyed line must be the center line where the greatest height of the terrace will occur. Both can be right and both can be wrong in certain situations of varying slopes in one terrace line. Keep an open mind regarding both practices and be ready to use either where it offers advantages. With the level and rod, all irregularities in the water line or in terrace height, may, and should be detected, before a rain occurs to show up the weak places.

After the terrace line is staked, it should be marked with a plow. Usually a man walks ahead of the team, using the stakes as his guide, but departing from them somewhat as his experience dictates. The team follows the man, not the stakes, which will sometimes form a very crooked or irregular line. These short sharp bends need not be made with the plow. The terrace should have easy rounding curves as water will not make sharp turns without cutting or clogging. If in walknig the line, we pass a stake on the downhill side, then we know we are on lower ground and the terrace must be built correspondingly higher at that point. If we pass a stake on the uphill side, then we know we are on higher ground, and that the terrace waterway must be correspondingly lower at that point to permit flow in the desired direction. Sometimes a hairpin bend in the terrace line may be avoided by careful thought to these methods. In rounding a hill or ridge, be careful not to get too high or a high place in the terrace line will result. Only slight variations from the surveyed line are permissible when walking the line. Figure 5 shows where a departure from the line was made to more quickly reach an outlet. The gully was formed in less than two years.

Building the Terrace. Terrace building should always begin at the top of the hill. The upper terrace should be finished before any of the lower terraces are started. A terrace is not finished until it is full height, wide enough to cross easily, has all gully fills made properly with extra allowance for settlement; has a wide, generous waterway and a wide, shallow outlet provided. Then if it has been checked over with the rod and level, it may be considered finished for the time being. If the upper terrace is not completely finished, a heavy rain may fall and leave the field in worse shape than it was before work started.

After the one furrow has been made to mark the terrace line if this is to be the center line of the terrace, back furrow to this as though a ridge is being made for sweet potatoes. The terrace must be two feet high along this line, and the object should be to obtain this height as quickly as possible. Plowing deep at this time will help to secure height. When three rounds have been made with the plow, at least one round should be made with the "V" drag or ditcher, then follow the plow with the drag. After about three

FIGURE 5

A Blaine County terrace section where a departure from the surveyed terrace line was made to reach a nearby outlet.

rounds with the "V" drag, make the fourth round of the drag catch the ridge of dirt that was left by the third round. This should put the dirt on top of the ridge. The job is to build a ridge that is at least 25 feet wide at the base, and at least two feet high on fairly steep land, and 28 to 36 feet wide and up

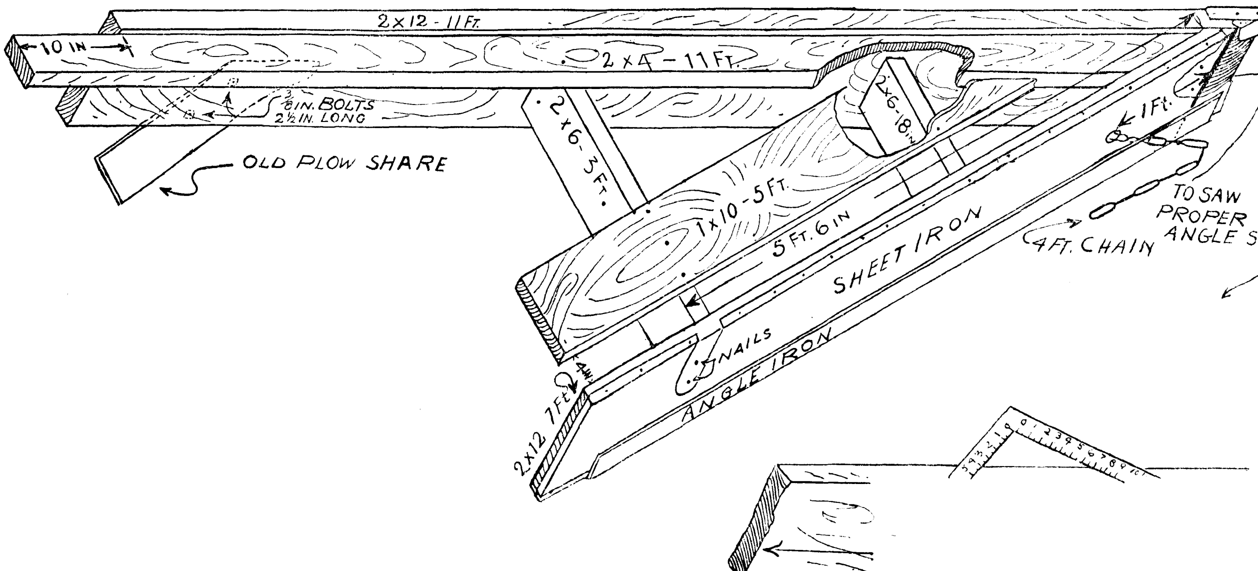


FIGURE 6—THE HOMEMADE V-DRAG

to 30 inches high for more gradual sloping land. Terraces on the Mangum farm are now 40 to 50 feet wide. The wider the terraces are, the less land will be lost to cultivation and the easier it will be to farm with large machinery. Nearly anyone can build a ridge if he knows the kind and size of ridge he should have. As already stated, the hardest part of terrace building is to get height. If the first furrow is turned uphill the second may be made to lap on top of the first, which is a gain in height. Some want to build all terraces from the upper side only. This may be done with certain easily reversible machines, but usually the time saved by going round and round offsets other advantages. The hard part of terrace building is to get height. When your terrace looks to be two feet high, measure it with the level and rod, and you probably will find it is about 12 inches high. Go back again and put it up. Extension service recommends a base width of 25 feet and a height of two feet for new terraces. Experience has shown that anything less than these dimensions is usually washed away. Therefore, these sizes are minimum, not standard sizes. There is no set standard size for a terrace. It must be big enough on the individual farm to do the job that the individual requires of it. Terrace height should be measured from the field surface on the upper side to the top of the ridge. Where a proper waterway is left, one that is wide and shallow, gradually merging into the field, the measurement may be from the average waterway to the top of the terrace, the difference should be two feet; one-fourth of this height will be lost in settling. There is no danger of getting them too high.

Experience in building terraces is the best help in getting the most out of the implements and power used. Knownig just where to stand on the wood drag, or how to properly handle your terracing machine so as to get the most dirt moved with the least effort is learned by experience. Terrace building necessitates the moving of large quantities of dirt which requires power and time. One should not expect to build a terrace in five or six rounds with any implement other than a sixty horse power caterpillar tractor and a twelve foot blade machine. The first terrace takes the longest to build because experience in handling the equipment has to be gained on the first terrace.

One object of terracing is to spread the rainfall out as far over the land as possible. This object is defeated if a narrow ditch is left along the top line of the terrace. Where such a ditch is left, water will collcet in it and run at considerable speed which may result in erosion along the terrace line.

The furrow walls left by the last round of the terracing tool should be cut down and the soil moved into the terrace. This is especially important on the low side of the terrace.

TERRACING IMPLEMENTS

A terrace may be made with a plow and a homemade "V" drag; with a ditcher or with a grader. Any of these will move dirt. Probably more terraces have been built with the plow "V" drag than with any other implement. The construction and dimensions of the "V" drag are shown in the accompanying figure. This drag has been found by experience to give good results in many different types of soil. It should be noted in the small drawing that the proper angle cut to obtain when the square rests at 4 inches on the tongue and 7 inches on the blade, as shown. This angle cut is made along the blade. Variations in the hitch are possible and will suggest themselves to the practical farmer.

A great improvement to the "V" drag results from using two rolling coulters to cut down side draft, instead of the plow share shown in Figure 6. The coulters and their axle housing are fastened with 2" x ⅜" strap iron, one on the inside front, the other immediately behind the 11 foot landside of the drag as shown in Figure 7. In loose trashy ground the coulters are a decided help. An improvement is made over the whole hitch shown in Figure 6, by bolting a piece of angle iron 2½" x 2½" x 8" in which three hitch holes have been drilled as shown in Figure 7, to the seven foot side of the drag in the position indicated by the hole in Figure 6. This results in a choice of three hitch positions.

As stated above, terrace building necessitates the moving of large quantities of soil. Any implement or machine which will shorten the time required for terrace construction will be worth a great deal to the user, especially on large tracts. A home made "V" will do the work but not very speedily.

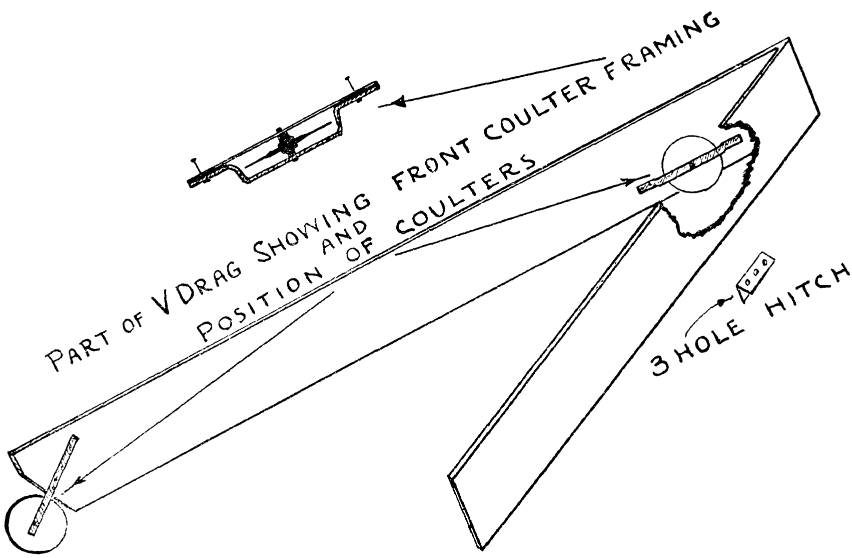


FIGURE 7

Figure 8 shows a steel "V" ditcher which is adjustable as to width and is made in three sizes. Figure 9 shows an all steel terracing machine built on the principle of a grader. There are two machines of the grader type now on the market, the Cosicana Grader and the Texas Terracer. The use of specially built machines is spreading in Oklahoma, doing away with the home-made drags. Terraces must be maintained so there is always a use for these machines on the farm.

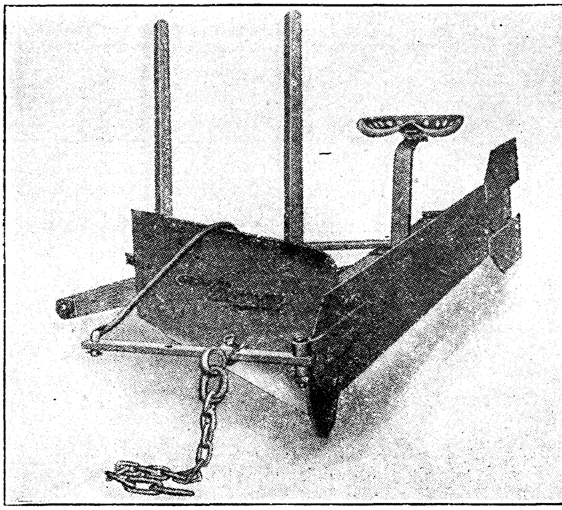


FIGURE 8

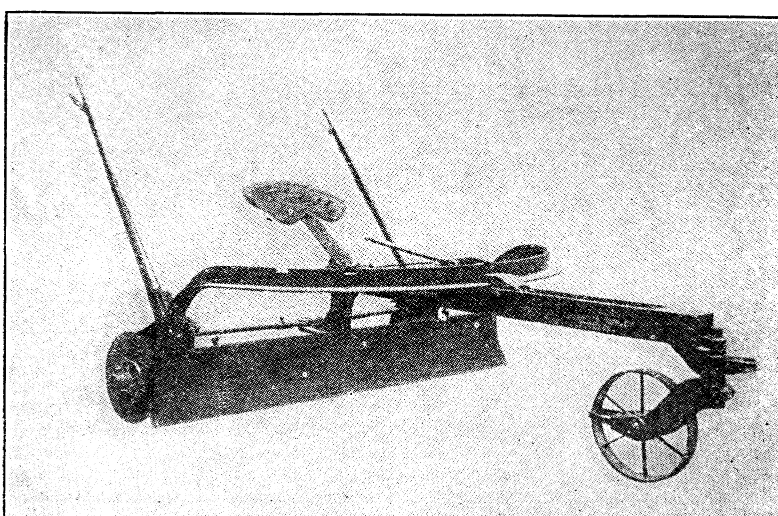


FIGURE 9

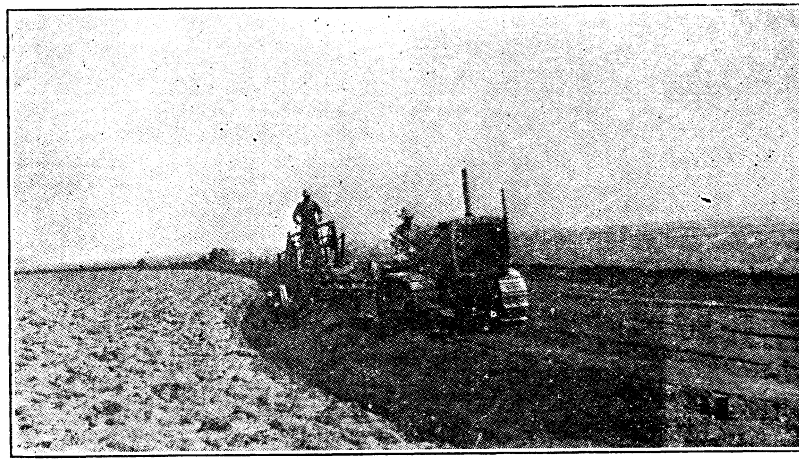


FIGURE 10

Figure 10 shows a power outfit that is very efficient for terrace work. A big advantage of the grader type of machine is that it cuts its own plow slice thus doing away with a plow, team and driver.

MAINTENANCE OF TERRACES

If terraces are built large in the beginning, their maintenance is an easy matter. Back-furrowing to the ridge once a year or a few rounds with the terrace grader is about all that will be necessary. It is important that attention be given to the terraces, while they are new, during and after heavy rains. Often a little work at the right time will prevent serious washing and gullying.

In breaking a terraced field it is well to take a plow land between the terraces. By starting the lands on top of the terraces they will be raised with each plowing, also there will be a dead furrow formed between the terraces which will aid in checking the water.

TERRACE OUTLETS

The two most common causes of failure in terracing are: poorly made fills, and small narrow outlets. As already stated, more water passes the outlet during very heavy rains than any other point of the terrace line.

If the terrace is to be emptied through a fence into a ditch outside the field, (See Figure 11) it is not sufficent to spread a narrow trench from the terrace waterway to the ditch. The outlet should be from 8 to 10 feet wide. It should not be deep. A broad, shallow outlet instead of a narrow one will frequently prevent a ditch eating back into the field. In some soils terrace outlets are not easily controlled and sometimes requires considerable careful work. Circular 219, dealing with this subject, may be obtained from your county agent or by writing the Extension division, A. and M. College, Stillwater, Oklahoma.

FIGURE 11
A COSTLY TERRACE OUTLET

A study of Figure 11 shows some interesting details. The boy setting on the terrace where one break occurred. There is another break just inside the fence line. The sand plain built up in the terrace waterway shows much movement of soil between the terraces which are too far apart. The concrete outlet is too small and then its line of throat clearance is immediately under the woven wire fence, with the result that the corn stalks have formed a soild mat on the fence preventing the escape of water, which resulted in terrace breaks. Had the line of throat clearance of the concrete outlet been placed inside the field, much of the clogging with trash would have been avoided.

CULTIVATION OF TERRACED FIELDS

As an excuse for not terracing, the statement is sometimes made that terracing makes the cultivation of the field difficult. In some cases cultivation will be a little more tedious, but it is work that pays well. Terracing should not cause trouble with a sowed crop, if the terraces are built broad so that implements can go over them easily .

The best way to run crop rows for conserving the soil and moisture and for protecting the terraces, is parallel with the ridge. Beginnnig at the center of the ridge, mark off one row on the upper side of the terrace, then mark off a row on the lower half of the next higher terrace, continue spacing rows from these till all long rows are in. The short rows will come midway between terraces and should be put in to the best advantage possible. Since each row will now have the same grade as the terrace, each row will carry its own water, and even distribution of moisture will occur over the whole field. This even distribution of moisture more than pays for the extra labor in planting and cultivation, and the added protection to the terrace is also worth more than the labor cost. Many Oklahoma farmers now use this system which is known as contour farming, and they will not use any other system on old or new terraced land because the extra yield makes this the most profitable system for them.

When the terraces are well established and their safety assured, a good way of running all the rows in the field parallel, is to use the central terrace as a guide row then perallel all rows to it. Most of the terraces will be crossed by a few of the rows but at an angle such as to prevent serious damage to the terrace. It is poor practice to run rows straight up and down the slope over the terraces and usually it results in failure. See Fig. 12, which shows an inspection party from the college at Stillwater out after a heavy rain.

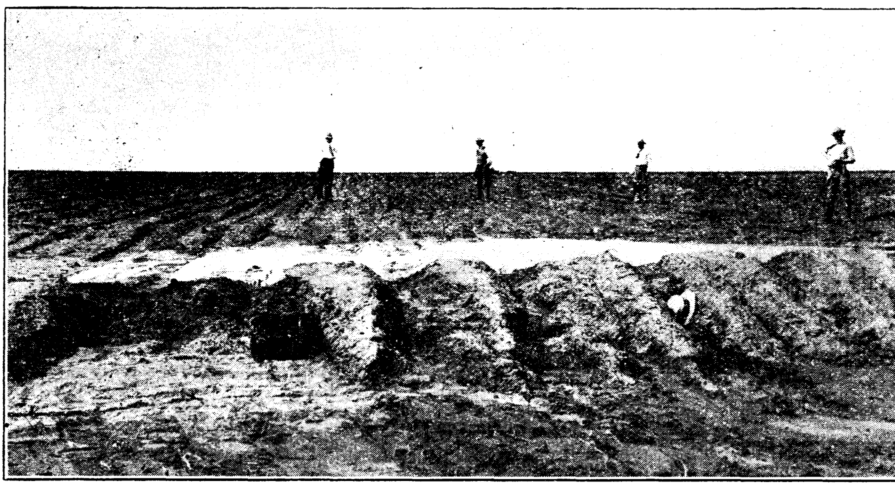


FIGURE 12

The result of running rows straight up and down hill over terraces.—(Note the camera case and the writer's hat in the foreground).

It is hard to understand just why level headed farmers will go to work at terracnig their farms, build good terraces and then run the rows straight up and down hill over the terraces, exposing their good work to certain failure if a heavy rain falls before the gaps are filled.

If there is one short stave in the barrel the water runs out—no matter how high the other staves are.

As with the short stave barrel, no matter how high terraces are built, if they are gapped with crop rows or with a dead furrow or in any way, they cannot hold water because their effective height is lowered. For every inch terrace height is lowered below the recommended height, the danger of failure is increased to where if the height is only 12 inches, fresh dirt, they had better not be built at all because their certain failure will ruin the field.

Terracing should be considered as the important first step in checking erosion and in rebuilding or retaining fertile soil. Good farming for profits will include with terracing, crop rotation, where selected crops are grown in definite order, and soil management which will include the addition of humus and other plant foods to the soil.

Figure 13 shows a terrace and the crop rows running with it. This terrace withstood the same rainfall conditions as shown in Figure 12.

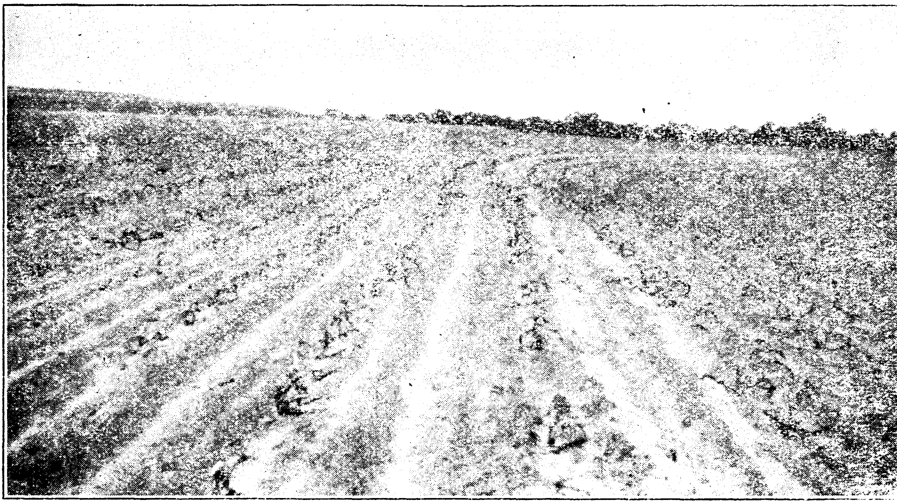


FIGURE 13
THE RESULT OF CONTOUR FARMING

Farmers who desire additional information or instruction in terracing their farms, or on crop rotation systems and soil management should confer with their county agents or write to the Extension Division, A. and M. College, Stillwater, Oklahoma.

The following series of agricultural engineering bulletins are available free at all county agent offices:

Leaflet—The Homemade Sweet Clover Seed Harvester.
245—Running Water in the Farm Home.
219—Methods of Controlling Gullies and Ditches.
224—Profile Leveling for 4-H Club Members.
175—The Farm Pond.
218—Terracing in Oklahoma.
231—The Septic Tank.
262—The Trench Silo.

Certain blueprint building plans are also available at a cost of 15 cents per sheet.

Issued by the Extension Service, Oklahoma A. and M. College, Stillwater.